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Sustainable synthesis of clean energy fuel Bio-ethanol from low cost biomass resources

Umesh Kumar[1], Amarpreet Singh Arora[2], Sachin Parikh[3]

[1]Environmental Engg., Marwadi Education Foundation's Group of Institutions, Rajkot. Umeshmalhotra4@gmail.com
[2]Environmental Engg., Marwadi Education Foundation's Group of Institutions, Rajkot. enviro_amar@yahoo.com
[3]Chemical Engineering, VVP Engineering College, Rajkot. sachinparikh@hotmail.com.

Abstract

Bio-ethanol is a domestically produced liquid fuel made from renewable plant resources know as biomass. This production of Bio-ethanol is an effective tool for reducing air toxic that comes from the transportation sector and is presently used as an alternative to the depleting resources. In this present study, bio-ethanol was produced by using 3various low cost raw biomasses which include paddy straws, paddy husk, and sugar cane beets. To produce ethanol from biomass two key processes were followed. Fist the starch or hemicelluloses and cellulose portions of the biomass were broken down into simple sugar through a process called saccharification. Second the sugars are fermented to produce ethanol. The enzyme were used for the hydrolysis of the biomass namely cellulose form Trichoderma viride. Cellulase was used for the hydrolysis of cellulose and hemicellulose. Enzymes were used for hydrolysis of the samples. 3 biomass types (sugar cane beets, Paddy straws and Paddy husk) were hydrolyzed by cellulase. The fermented product was purified by primary distillation process at 80 ^{0}C and fraction was collected and determined by specific gravity method. Further study can be done to yield more amount of ethanol by optimizing the activity of enzymes over biomass, incubate temperature incubate time and by secondary distillation after primary distillation.

Keywords- *Bioethanol, cellulose, fermentation,, hemicelluloses, distillation, biomass*

I. INTRODUCTION

A great fraction of the world's energy requirements are presently met through the unfettered use of fossil-derived fuels [1, 2]. However, due to the anticipated demise of these energy sources and the environmental and socioeconomic concerns associated with their use, a recent paradigm shift is to displace conventional fuels with renewable energy sources [3, 4]. Among various alternatives, biomasses have gained tremendous interests as potential feedstock for clean energy production.

Bio-ethanol is by far the most widely used bio-fuel for transportation worldwide. Production of bio-ethanol from biomass is one way to reduce both consumption of crude oil and environmental pollution [5].

The increase in bio-fuels utilization has also been accompanied over the past 3–4 years by policy decisions that encourage future growth of these fuels. In North America, policies that help grain based ethanol compete in the market were extended, and additional policies to increase bio-diesel utilization are being discussed [8,9]. In Europe, guidelines to ensure motor fuels contain certain levels of alternate fuels have been established, and bio-fuels are expected to be the primary way these goals are met. In South America, Brazil also continued policies that mandate at least 22% ethanol in engine fuels and encourage the use of vehicles that use hydrous ethanol to replace gasoline. In the past decade, the use of bio-fuels has increased dramatically to a total volume of approximately 30 billion liters in 2003. The increase in the use of bio-diesel has been particularly rapid, growing from essentially zero in 1995 to more than 1.5 billion liters in 2003. The use of ethanol and ethanol derived ethyl-tertiary-butyl-ether (ETBE) has also grown steadily, experiencing a nearly threefold increase in a decade[6]

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The international bio-fuel market is still at an early and very dynamic stage. Future conditions for an inter-national bio-fuel market in Europe will largely be decided by the European Union (EU) policies on renewable energy and their interplay with national energy policies. So far, the Commission has indicated that biomass will play an important role in the future. In that context, bio-fuel trade seems to be a plausible scenario for the world. It is likely that seemingly strange trade flows will appear and disappear as this new fuel market evolves [7, 10, 11]. The current paper thus presents insights into the use of low cost biomass resource available for producing Bio-ethanol, a clean energy fuel.

II. MATERIALS AND METHODS

Presently various low cost raw materials are used for the production of Bioethanol. A typical biomass contain about 45% of hexose, 30% pentose and 25% other substance. Pentose (mostly xylose) cannot be fermented by traditional ethanol producing yeast. Thus genetically engineered spices are used for the utilization of xylose. However, to make the ethanol production process economically feasible, several research challenges remain in order to further improve the overall yield of both ethanol and solid fuel, increase the productivity in the conversion steps and to reduce the production cost. The methodology adopted in the present study is explicated below.

2.1. Sample collection

The current study involved the collection of three low cost biomass samples namely Sugar cane beets, Paddy straws and Paddy husk.

2.2 Production of enzymes

Sugar cane beets, Paddy straws and Paddy husk were hydrolyzed by the enzyme cellulase.

2.3 Pretreatment and Enzymatic Hydrolysis of the Substrate

Sugar cane beet, Paddy husk and Paddy straws were cut into small pieces and weighed. 50g of each was taken in a clean beaker and 300 ml of distilled water was added and then boiled for about 20-30 min. After boiling the extract was taken in a clean conical flask. The sugar beet was squeezed using a muslin cloth to get more extract. About 150 ml of the extract was taken in 250 ml Erlenmeyer flask, then autoclaved at 121˚C for 15 min at 15 lbs. After cooling, 10 ml of cellulase was added into the extract and kept in the shaking incubator for about 3 hours.

2.4 Fermentation of the Substrate

After the enzymatic hydrolysis, all the samples were kept for fermentation. Fermentation was done by adding aseptically 5-6 granules of baker's yeast into the broth. Fermentation was carried out in the rotary shaker for 7 day at room temperature. Separate hydrolysis and fermentation (SHF) was technique was employed here.

2.5 Distillation of the Substrate

After fermentation, the fermented substrates were taken in a round bottom flask for distillation and the flask was kept in boiling water bath for 6-7 hours at 80˚ C, that condense the ethanol and ethanol is separated out in a tube and procedure is repeated.

2.6 Purification of the Substrate

Specific gravity bottle was cleaned thoroughly with a mixture of chromic acid and nitric acid followed by thorough washing with water. It was rinsed with distilled water and finally with alcohol, it was dried in oven. Weigh the empty specific gravity bottle with stopper. With the help of pipette add the ethanol to the specific gravity bottle and its weight is measured along the stopper. Remove the alcohol from the specific gravity bottle and dried in oven. The dried specific gravity bottle was filled with distilled water avoiding any air bubble and stopped in the same manner and weighted accurately. Note the room temperature. The calculation for the specific gravity was done using the following equation

$$\text{Specific gravity} = \frac{\text{Weight of alcohol X Density of water}}{\text{Weight of water}}$$

These processes were applied for all the 3 samples and the result was noted.

III. RESULTS AND DISCUSSION

For the production of bio-ethanol 3 different samples, which were rich in starch and cellulose were collected. These samples were then pretreated by cutting into small pieces and then boiled using distilled water. Boiling was done to break the linkage of starch and cellulose so that the hydrolysis of carbohydrate fraction to monomeric sugar can be achieved more rapidly and with greater yield.

The pretreatment is followed by the hydrolysis by using the enzymes. The enzyme used was cellulase. This enzyme is very specific in breaking beta glycosidic linkage of cellulose. By hydrolysis the complex polysaccharides are converted to monosaccharides. These monosaccharides are converted to ethanol by fermentation process.

Mainly glucose is formed after hydrolysis. Glucose undergo glycolytic pathway to form pyruvate. This pyruvate is then converted to ethanol under anaerobic condition.

Distillation is the process for the purification of ethanol. To get the pure ethanol several distillations has to be performed. The distillation is based upon the varying boiling temperature of the liquid. Each component has its specific boiling temperature at which it get vaporized. The boiling point of ethanol is 173.37 F and at this temperature only the ethanol gets vaporized. The vaporized ethanol is condensed by low temperature and gets separated. The product so obtained is known as the distillate.

The specific gravity method is done to determine the concentration of ethanol. The specific gravity of pure ethanol should be read close to 0.789 at 28 degree. In this result the specific gravity of the 6 samples were ranging from 0.8 to 1. Its shows that the ethanol produced are pure but also contain some impurities. Pure ethanol is obtained only after several distillations

Table 1 shows the results obtained and the volume of bio-ethanol extracted from the 3 low cost biomass resources.

Table 1: Comparison of the Volume of Bio-ethanol extracted

S.No.	Sample	Volume of extract before distillation in ml	Volume of extract after distillation in ml	*Volume of* Bioethanol after distillation in ml
1	*Paddy husk*	*150*	*148*	*1.5*
2	*Paddy straws*	*150*	*148*	*1.5*
3	*Sugarcane beet*	*150*	*146*	*3.5*

Among the 3 samples, sugarcane beet produced the maximum amount of bio-ethanol (3.5 ml).

IV. CONCLUSIONS

For the production of bio-ethanol 3 different samples were collected. Paddy husk, Paddy straws, and sugar cane beets, were collected from local market. The collected samples were then pretreated by boiling.

The pretreated samples were then hydrolyzed cellulase for the hydrolysis of Paddy husk, Paddy straws, and sugar cane beets. The hydrolysis samples were then fermented using dried yeast (Saccharomyces cervisae) for 7 days in shaker incubator. The fermented samples were distillated at 80 ˚ C for 7 -8 hours. At this temperature the ethanol gets vaporized and gets condensed to form ethanol.

The concentration of ethanol was determined by specific gravity method which showed a positive result for all the samples. Among the 3 different samples, sugar cane beet produced the maximum amount of ethanol.

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